PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-254208
(43)Date of publication of application : 10.09.2002

(51)Int.Cl. B23B 27/14
B23C 5/16
C23C 14/06

(21)Application number : 2001-048864
(22)Date of filing : 23.02.2001

(71)Applicant : HITACHI METALS LTD
(72)Inventor : INOUE KENICHI

(54) TOOL HAVING EXCELLENT OXIDATION RESISTANCE AND WEAR RESISTANCE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a tool having excellent oxidation resistance compared to conventional TiAlN coating tools, and having excellent oxidation resistance and wear resistance matching with a trend toward high speed metal cutting.
SOLUTION: The tool is coated with a hard coating film on its base material. In the hard coating film, one or more layers of an 'a' layer and a 'b' layer are alternately coated respectively on the surface of the base material so that the 'b' layer is next to the surface of the coated base material, where the 'a' layer is a nitride composed of Si of 5 to 50% in an atomic percentage in a metallic component only and the remainder substantially composed of one or two types of Al and W, and the 'b' layer is a nitride composed of Al of 40 to 60%, Si of 10 to 20% in an atomic percentage in a metallic component only and the remainder substantially composed of Ti. The thickness of the 'a' layer is preferably 0.1 to 3 μm. Further, it is preferable to coat the hard coating film by a physical deposition method.

LEGAL STATUS
[Date of request for examination]
[Date of sending the examiner's decision of rejection]
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] It is the tool which comes to cover hard anodic oxidation coatings on a base material front face. The hard anodic oxidation coatings atomic % of only a metal component -- Si: -- 5 to 50% with a layers which are the nitrides which consist of one sort of the remainder, and aluminum and W, or two sorts substantially It exceeds Si:10% 40 to 60%. atomic % of only a metal component -- aluminum: -- The tool excellent in the oxidation resistance and abrasion resistance which are characterized by covering further substantially b layers whose remainders are the nitrides which consist of Ti by turns above 20% or less, respectively, and there being b layers in right above [covering base material surface].
[Claim 2] The tool excellent in the oxidation resistance according to claim 1 and the abrasion resistance which are characterized by the thickness of a layers being 0.1-3 micrometers.
[Claim 3] Hard anodic oxidation coatings are the tools excellent in oxidation resistance and abrasion resistance given in claims 1 and 2 characterized by covering with physical vapor deposition.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to the tool which covered hard anodic oxidation coatings excellent in oxidation resistance and abrasion resistance useful especially as a surface coating material about tools used mainly for processing of a metallic material etc., such as a cutting tool and metal mold.
[0002]
[Description of the Prior Art] Conventionally, TiN, TiCN(s), or those compound coats of the hard anodic oxidation coatings used for a cutting tool, metal mold, etc. were common. Since TiN is excellent in oxidation resistance compared with TiCN, the outstanding abrasion resistance is not only shown to the oxidative wear of the tool produced by generation of heat at the time of processing, but it is the features that adhesion with a base material is also good. Moreover, compared with TiN, it is a high degree of hardness, and since coefficient of friction is also low, TiCN shows the property which was excellent to sliding wear of a tool.
[0003] It could not be satisfied with the above-mentioned hard anodic oxidation coatings of oxidation resistance, and stopped however, showing sufficient engine performance to the high speed inclination of the working speed aiming at the high promotion of efficiency of metalworking of these days. The TiAlN coat which the research which raises the oxidation resistance of a coat and abrasion resistance more is made, consequently is represented by JP,62-56565,A and JP,2-194159,A from such a background is developed, and the cutting tool is applied by the subject.
[0004]
[Problem(s) to be Solved by the Invention] Although a TiAlN coat changes with component ratios of Ti and aluminum contained in the coat, since oxidation resistance is remarkably excellent compared with said TiN and TiCN, it raises [the Vickers hardness number of outlines 2300-2800 / not only /, but] the engine performance of a tool remarkably under a processing condition like especially high-speed-cutting processing to which the edge of a blade reaches an elevated temperature. However, in recent years, in addition to the inclination which working speed accelerates further, importance is attached to reduction of the amount of the lubricant used, or processing by dry type on an environmental problem, and the operating environment of a tool has become a high temperature load, and the reduction in lubrication and a still crueller thing.
[0005] According to research of this invention person, the oxidation initiation temperature of the TiAlN coat in atmospheric air improves at about 750-900 degrees C to 450 degrees C of TiN depending on the addition of aluminum. However, in the above-mentioned dry type high-speed-cutting processing, since the edge-of-a-blade temperature of the tool to be used reaches an elevated temperature 900 degrees C or more, the present condition is that tool life sufficient by said TiAlN coat is not acquired.
[0006] It is establishing the hard anodic oxidation coatings which this invention's is made in view of such a situation, have the oxidation resistance which was excellent compared with the conventional TiAlN coat, and were excellent in the oxidation resistance and abrasion resistance corresponding to improvement in the speed of metalworking, and it is the purpose to offer the tool excellent in oxidation resistance and abrasion resistance.
[0007]
[Means for Solving the Problem] this invention person performed examination detailed about the effect of various elements affect the oxidation resistance of the hard anodic oxidation coatings covered by the base material front face, abrasion resistance, and adhesion with a base material, and the layer structure of a coat. Consequently, the coat of the nitride which consists of one sort of aluminum and W which carried out optimum dose content of the Si, or two sorts, Each metal component contained in them in the coat of the nitride which used Si, aluminum, and Ti as the principal component is restricted in a specific value. In case it covers by turns above further, respectively, the coat of the nitride which used Si, above-mentioned aluminum, and above-mentioned Ti as the principal component by and the thing to carry out to right above [covering base material surface] The oxidation resistance and abrasion resistance of a coat improved remarkably, found out that the tool engine performance especially in high-speed processing became very good, and reached this invention.
[0008] This invention is a tool which comes to cover hard anodic oxidation coatings on a base material front face. Namely, the hard anodic oxidation coatings atomic % of only a metal component — Si: — 5 to 50% with a layers which are the nitrides which consist of one sort of the remainder, and aluminum and W, or two sorts substantially atomic % of only a metal component — aluminum: — it is the tool characterized by exceeding Si:10%, and covering further above b layers which are the nitrides with which the remainder consists of Ti substantially by turns 20% or

less 40 to 60%, respectively, and there being b layers in right above [covering base material surface]. In addition, as for a layers of the hard anodic oxidation coatings of this invention, it is desirable that it is 0.1-3-micrometer thickness, and, as for the hard anodic oxidation coatings of this invention, having been covered with physical vapor deposition is still more desirable.
[0009]
[Embodiment of the Invention] The requirement for a configuration is first described in detail about a layers of the hard anodic oxidation coatings of a publication among a claim.
[0010] Generally, aluminum near the coat front face will carry out extroversion diffusion in the outermost surface, and a TiAlN coat will form aluminum oxide layer there, if an oxidation test is performed in atmospheric air. Generally, although formation of this aluminum oxide layer is called reasons of an anti-oxidation disposition, at this time, directly under aluminum oxide layer, aluminum is contained and twisted and the layer of porous Ti oxide forms very much.
[0011] According to research of this invention person, although the layer of aluminum oxide formed in the outermost surface functions as a protective coat in a static oxidation test to turning-inward diffusion of the oxygen which advances oxidation of a coat, the above-mentioned TiAlN coat In the case where it actually applies to a tool, it was admitted that the layer of aluminum oxide of the outermost surface exfoliated easily, and did not demonstrate the effectiveness from the layer of Ti oxide porous directly under it enough to advance of oxidation by stress, an impact, etc. at the time of processing. It not only improves the oxidation resistance of a coat, but from these, it was expected at the time of oxidation that the engine performance of hard anodic oxidation coatings can be further improved by improving the porous layer formed directly under an oxidation protective coat in a precise gestalt.
[0012] As a result of inquiring based on the above-mentioned idea, a metal component then, Si of optimum dose and the coat of the nitride with which the remainder consists of one sort of aluminum and W, or two sorts substantially As opposed to the conventional TiAlN coat it not only excels in oxidation resistance extremely, but It checked forming in the outermost surface after oxidation the very precise oxide layer which contains Si used as an oxidation protective coat to a subject, and not forming the porous oxide layer leading to [of an oxidation protective coat] exfoliation directly under it.
[0013] In order to acquire the above-mentioned effectiveness, when it must be added 5% or more and Si contains by atomic % of only a metal component exceeding 50% to one sort of aluminum and W which are the remainder substantially, or two sorts conversely, the adhesion fall of a coat becomes remarkable and it becomes impossible to be equal to the use as a tool. The desirable range of Si is 10 - 40% in atomic % of only the metal component of a coat.
[0014] As for a layers of the hard anodic oxidation coatings in this invention, it is desirable that there is the thickness by 0.1 micrometers - 3 micrometers. When the thickness of a layers is less than 0.1 micrometers, to turning-inward diffusion of oxygen, thickness may not be enough and the anti-oxidation disposition top effectiveness does not appear notably. Moreover, if the thickness of a layers exceeds 3 micrometers, an opportunity for destruction of a layers or exfoliation to generate will increase while in use. Therefore, the thickness of a layers has 0.1 micrometers - desirable 3 micrometers.
[0015] Although the a above-mentioned layers have static and the oxidation resistance which was excellent under the dynamic condition, they are not enough in adhesion with a base material. Therefore, it is required for right above [base material surface] with sufficient balance to cover b layers of a publication in a claim which are coats with adhesion, abrasion resistance, oxidation resistance, etc. moderately.
[0016] The role of aluminum in b layers is raising the abrasion resistance and the oxidation resistance of a coat. It becomes good [the adhesion of a base material and a coat] so that there are few aluminum contents in a coat, but if it is atom [of only the metal component of a coat] % and aluminum becomes less than 40%, the effectiveness of raising the abrasion resistance of a coat and oxidation resistance will not be acquired. However, if contained exceeding 60%, the adhesion of a base material and a coat not only deteriorates, but the hardness of a coat will also fall conversely and abrasion resistance required as a tool will not be obtained. Therefore, in order to acquire adhesion, abrasion resistance, and oxidation resistance with sufficient balance, it is important to be atom [of only the metal component of a coat] % and to adjust aluminum content of b layers to 40 - 60%.
[0017] Moreover, in the b above-mentioned layers, Si has effectiveness in improvement in oxidation resistance and coating hardness. In order to acquire this effectiveness, it is required to make Si contain by atomic % of only a metal component exceeding 10%, but if it is made to contain exceeding 20%, the adhesion of b layers will fall remarkably. Therefore, when it applies to a tool, in order to acquire adhesion, abrasion resistance, and oxidation resistance with sufficient balance by high order origin, it is important to be atom [of only the metal of a coat] % and to make Si content of b layers 20% or less exceeding 10%.
[0018] As mentioned above, in the tool of this invention, b layers with the abrasion resistance and the oxidation resistance of adhesion with a base material and the coat itself are covered with high order origin with sufficient balance right above [base material surface], it is very important to cover a layers which are remarkably excellent in oxidation resistance on it, consequently a cutting tool, metal mold, etc. which become usable enough to processing under low lubrication or high-speed processing can be obtained. Moreover, after covering b layers right above [base material surface], the same effectiveness is acquired also by the multilayer coat which carried out the laminating of a layers and the b layers by turns, respectively.
[0019] Although they are not limited especially about the covering approach, when the thermal effect to a covering base material, the fatigue strength of a tool, the adhesion of a coat, etc. are taken into consideration, as for the hard

anodic oxidation coatings covered by the tool of this invention, it is desirable that it is the physical vapor deposition which impresses bias voltage to a covering base material side, such as arc discharge method ion plating to which compressive stress remains to the coat which could cover with low temperature comparatively and was covered, or sputtering.
[0020]
[Example] Next, although explained to a detail based on an example, this invention cannot receive limitation according to the following example, and can be changed into arbitration in the range which does not deviate from the summary of this invention, and each of they is contained in the technical range of this invention.
[0021] The various targets made from an alloy which are the evaporation sources of a metal component using a small arc ion plating system, And, impressing the potential of −50V to 6 cutting-edge end mill with an outer diameter of 8mm which is a covering base made from cemented carbide, and carrying out five revolutions to it in 1 minute under conditions of the covering base temperature of 400 degrees C, and 3.0Pa of reagent-gas-pressure force, using N2 gas as reactant gas Membranes were first formed right above [covering base surface] as b layers, and membranes were formed so that the thickness of all coats might be set to about 4 micrometers.
[0022] The obtained hard anodic oxidation coatings measured class thickness by the quantum of the coat presentation by the Auger-analysis method, and scanning electron microscope observation of a coat cross section, and evaluated cutting-ability ability by the dry type high-speed-cutting conditions shown further below. At this time, processing was continued until it became impossible by a chip or wear of the edge of a blade etc. cutting a tool, and the length of cut at this time was made into the tool life. The detail of the hard anodic oxidation coatings about the example of this invention and the example of a comparison and its cutting-ability ability evaluation result are shown in Tables 1 and 2. Moreover, the evaluation result of the conventional example is collectively shown in Table 3.
[0023] (Cutting conditions)
Tool : 6 cutting-edge end mill made from cemented carbide The outer-diameter cutting approach of 8mm: Side-face cutting down cutting, **-ed [Ayr blow] material : SKD11 (hardness 60HRC)
Slitting: Ad 12 mmxRd 0.4mm cutting speed: 150 m/min delivery : 0.03 mm/tooth [0024]
[Table 1]

		a層		b層		総積層数 (a層+b層)	工具寿命 (m)
		皮膜組成	層厚 (μm)	皮膜組成	層厚 (μm)		
本発明例	1	$(Al_{0.76}Si_{0.24})N$	1．0	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	3．0	2	50．8
	2	$(Al_{0.76}Si_{0.24})N$	0．4	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	0．4	10	49．8
	3	$(W_{0.87}Si_{0.13})N$	1．0	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	3．0	2	49．8
	4	$(Al_{0.67}Si_{0.33})N$	1．0	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	3．0	2	50．2
	5	$(Al_{0.40}W_{0.37}Si_{0.23})N$	0．2	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	0．2	20	50．2
	6	$(Al_{0.76}Si_{0.24})N$	0．5	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	3．5	2	50．4
	7	$(Al_{0.40}W_{0.37}Si_{0.23})N$	1．0	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	3．0	2	50．2
	8	$(Al_{0.67}Si_{0.33})N$	0．2	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	0．2	20	50．2
	9	$(W_{0.87}Si_{0.13})N$	0．2	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	0．2	20	49．6
	10	$(W_{0.78}Si_{0.22})N$	0．5	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	3．5	2	50．2
	11	$(Al_{0.86}Si_{0.14})N$	0．4	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	0．4	10	50．2
	12	$(W_{0.87}Si_{0.13})N$	0．2	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	0．6	10	49．8
	13	$(W_{0.78}Si_{0.22})N$	1．0	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	3．0	2	50．8
	14	$(Al_{0.76}Si_{0.24})N$	0．2	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	0．6	10	50．0
	15	$(Al_{0.86}Si_{0.14})N$	1．0	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	3．0	2	50．2
	16	$(W_{0.78}Si_{0.22})N$	0．5	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	3．5	2	50．2
	17	$(Al_{0.76}Si_{0.24})N$	0．2	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	0．1	20	49．6
	18	$(Al_{0.67}Si_{0.33})N$	1．0	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	3．0	2	50．8
	19	$(W_{0.78}Si_{0.22})N$	0．4	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	0．4	10	50．2
	20	$(Al_{0.76}Si_{0.24})N$	1．0	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	3．0	2	50．6
	21	$(W_{0.78}Si_{0.22})N$	0．2	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	0．2	20	50．0
	22	$(Al_{0.40}W_{0.37}Si_{0.23})N$	0．5	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	3．5	2	50．4
	23	$(Al_{0.86}Si_{0.14})N$	0．5	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	3．5	2	50．4
	24	$(W_{0.78}Si_{0.22})N$	0．2	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	0．6	10	49．8
	25	$(W_{0.87}Si_{0.13})N$	0．5	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	3．5	2	49．6

[0025]
[Table 2]

		a層		b層		総積層数（a層＋b層）	工具寿命（m）
		皮膜組成	層厚（μm）	皮膜組成	層厚（μm）		
比較例	31	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	0.4	$(Al_{0.76}Si_{0.24})N$	0.4	10	5.0
	32	$(Al_{0.76}Si_{0.24})N$	1.0	$(Ti_{0.44}Al_{0.52}Si_{0.04})N$	3.0	2	35.8
	33	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	1.0	$(W_{0.78}Si_{0.22})N$	3.0	2	4.8
	34	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	0.4	$(W_{0.87}Si_{0.13})N$	0.4	10	4.4
	35	$(W_{0.40}Si_{0.60})N$	1.0	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	3.0	2	30.4
	36	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	3.0	$(Al_{0.76}Si_{0.24})N$	1.0	2	5.4
	37	$(W_{0.99}Si_{0.01})N$	1.0	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	3.0	2	31.6
	38	$(Al_{0.98}Si_{0.02})N$	1.0	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	3.0	2	32.2
	39	$(W_{0.78}Si_{0.22})N$	0.5	$(Ti_{0.44}Al_{0.52}Si_{0.04})N$	3.5	2	35.6
	40	$(Al_{0.76}Si_{0.24})N$	1.0	$(Ti_{0.48}Al_{0.52})N$	3.0	2	35.8
	41	$(Al_{0.37}Si_{0.63})N$	0.5	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	3.5	2	29.8

[0026]
[Table 3]

		皮膜構造および組成	工具寿命（m）
従来例	51	$(Ti_{0.52}Al_{0.48})N$ 単一層	27.6
	52	TiN（基体側1.0μm）＋（$Ti_{0.52}Al_{0.48}$)N（表面側3.0μm）	24.4
	53	$(Ti_{0.41}Al_{0.59})N$ 単一層	28.2
	54	TiN（基体側1.0μm）＋（$Ti_{0.41}Al_{0.59}$)N（表面側3.0μm）	27.6

[0027] As shown in Table 1, 2, and 3, it turns out that the tool life has extended the example of this invention remarkably compared with the example of a comparison, and the conventional example. Although contained [examples / in Table 2 / of a comparison / 31, 33, 34, and 36] in this invention about the presentation of a coat, since the layer structures of a coat differed, at an early stage, exfoliation arose and a result of a short life was extremely brought from the interface of a coat and a base material. Moreover, the examples 35 and 41 of a comparison had many Si contents of a layers, and since exfoliation of a layers arose in the phase in early stages of cutting, they became a tool life almost equivalent to the conventional example.
[0028] On the other hand, although the tool life all resulted in it being excellent about the examples 32, 37, 38, 39, and 40 of a comparison compared with the conventional example, a remarkable improvement effect like the example of this invention was not accepted. In the examples 32, 37, 38, and 39 of a comparison, about that there are few Si contents in a layers or b layers, and the example 40 of a comparison, this is not containing Si in b layers, and the oxidation resistance of a coat considers it because it has not fully [example / of this invention] been improved.
[0029]
[Effect of the Invention] Compared with the tool which comes to cover the conventional TiAlN coat, since [/ the outstanding oxidation resistance and abrasion resistance], the tool which comes to cover the hard anodic oxidation coatings of this invention can be dealt with improvement in the speed of metalworking, and is very effective in improvement in productivity.

[Translation done.]

引用文献5

(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（Ａ）　(11)特許出願公開番号
特開2002−254208
(P2002−254208A)
(43)公開日　平成14年9月10日(2002.9.10)

(51)Int.Cl.7	識別記号	ＦＩ	テーマコード*(参考)
Ｂ２３Ｂ　27/14		Ｂ２３Ｂ　27/14	Ａ　３Ｃ０４６
Ｂ２３Ｃ　5/16		Ｂ２３Ｃ　5/16	４Ｋ０２９
Ｃ２３Ｃ　14/06		Ｃ２３Ｃ　14/06	Ｐ
			Ａ

審査請求　未請求　請求項の数３　ＯＬ　（全５頁）

(21)出願番号　特願2001−48864(P2001−48864)

(22)出願日　平成13年2月23日(2001.2.23)

(71)出願人　000005083
日立金属株式会社
東京都港区芝浦一丁目２番１号

(72)発明者　井上　謙一
島根県安来市安来町2107番地２　日立金属株式会社冶金研究所内

Ｆターム(参考)　3C046 FF03 FF10 FF13 FF16 FF19 FF25
4K029 BA58 BB02 BC01 BC02 BD05 EA01

(54)【発明の名称】　耐酸化性および耐摩耗性に優れた工具

(57)【要約】
【課題】　従来のＴｉＡｌＮ皮膜を被覆した工具に比べ優れた耐酸化性を有し、金属加工の高速化に対応する耐酸化性および耐摩耗性に優れた工具を提供する。
【解決手段】　母材表面に硬質皮膜を被覆してなる工具であって、その硬質皮膜は、金属成分のみの原子％が、Ｓｉ：５〜５０％、実質的に残部、Ａｌ、Ｗの１種もしくは２種で構成される窒化物であるａ層と、金属成分のみの原子％が、Ａｌ：４０〜６０％、Ｓｉ：１０％越え、２０％以下、実質的に残部がＴｉで構成される窒化物であるｂ層とが、それぞれ一層以上交互に被覆されたものであり、かつｂ層が被覆母材表面直上にある工具である。ａ層の層厚が０．１〜３μｍであることが好ましい。なお、硬質皮膜は、物理蒸着法により被覆することが望ましい。

1

【特許請求の範囲】

【請求項１】　母材表面に硬質皮膜を被覆してなる工具であって、その硬質皮膜は、金属成分のみの原子％が、Ｓｉ：５～５０％、実質的に残部、Ａｌ、Ｗの１種もしくは２種で構成される窒化物であるａ層と、金属成分のみの原子％が、Ａｌ：４０～６０％、Ｓｉ：１０％越え、２０％以下、実質的に残部がＴｉで構成される窒化物であるｂ層とが、それぞれ一層以上交互に被覆されたものであり、かつｂ層が被覆母材表面直上にあることを特徴とする耐酸化性および耐摩耗性に優れた工具。

【請求項２】　ａ層の層厚が０．１～３μｍであることを特徴とする請求項１に記載の耐酸化性および耐摩耗性に優れた工具。

【請求項３】　硬質皮膜は、物理蒸着法により被覆したことを特徴とする請求項１および２に記載の耐酸化性および耐摩耗性に優れた工具。

【発明の詳細な説明】

【０００１】

【発明が属する技術分野】本発明は、主として金属材料等の加工に使用される切削工具、金型等の工具に関し、特に表面コーティング材として有用な耐酸化性および耐摩耗性に優れた硬質皮膜を被覆した工具に関するものである。

【０００２】

【従来の技術】従来、切削工具および金型等に用いられる硬質皮膜は、ＴｉＮ、ＴｉＣＮもしくはそれらの複合皮膜が一般的であった。ＴｉＮはＴｉＣＮに比べ、耐酸化性に優れるため、加工時の発熱によって生じる工具の酸化摩耗に対して、優れた耐摩耗性を示すだけでなく、母材との密着性も良好であることが特長である。また、ＴｉＣＮは、ＴｉＮに比べ高硬度であり、かつ摩擦係数も低いため、工具の摺動摩耗に対して優れた特性を示す。

【０００３】しかしながら、昨今の金属加工の高能率化を目的とした加工速度の高速化傾向に対し、上記硬質皮膜では、耐酸化性が満足できず十分な性能を示さなくなった。この様な背景から、皮膜の耐酸化性、耐摩耗性をより向上させる研究がなされ、その結果、特開昭６２－５６５６５号、特開平２－１９４１５９号に代表されるＴｉＡｌＮ皮膜が開発され切削工具を主体に適用されている。

【０００４】

【発明が解決しようとする課題】ＴｉＡｌＮ皮膜は、その皮膜中に含有するＴｉとＡｌの成分比率により異なるものの、概略２３００～２８００のビッカース硬さを有すだけではなく、耐酸化性が前記ＴｉＮ、ＴｉＣＮに比べ著しく優れるため、特に高速切削加工のような、刃先が高温に達する加工条件下においては、工具の性能を著しく向上させる。しかしながら、近年では更に加工速度が高速化する傾向に加え、環境問題上、潤滑剤使用量の低減もしくは乾式による加工が重要視され、工具の使用環境は、高熱負荷、低潤滑化とますます苛酷なものとなってきた。

2

【０００５】本発明者の研究によれば、大気中におけるＴｉＡｌＮ皮膜の酸化開始温度は、ＴｉＮの４５０℃に対し、Ａｌの添加量に依存して約７５０～９００℃に向上する。しかしながら、前述の乾式高速切削加工においては、使用する工具の刃先温度が９００℃以上の高温に達するため、前記ＴｉＡｌＮ皮膜でも、十分な工具寿命が得られないのが現状である。

【０００６】本発明はこうした事情に鑑みなされたものであって、従来のＴｉＡｌＮ皮膜に比べ優れた耐酸化性を有し、金属加工の高速化に対応する耐酸化性および耐摩耗性に優れた硬質皮膜を確立することで、耐酸化性および耐摩耗性に優れた工具を提供することが目的である。

【０００７】

【課題を解決するための手段】本発明者は、母材表面に被覆される硬質皮膜の耐酸化性、耐摩耗性、母材との密着性に及ぼす、様々な元素の影響および皮膜の層構造について詳細な検討を行った。その結果、Ｓｉを適量含有した、Ａｌ、Ｗの１種もしくは２種で構成される窒化物の皮膜と、Ｓｉ、Ａｌ、Ｔｉを主成分とした窒化物の皮膜を、それらに含まれる各金属成分を特定値内に制限し、かつ、それぞれ一層以上交互に被覆する際、上述のＳｉ、Ａｌ、Ｔｉを主成分とした窒化物の皮膜を被覆母材表面直上にすることで、皮膜の耐酸化性ならびに耐摩耗性が著しく向上し、特に高速加工における工具性能が極めて良好となることを見いだし、本発明に到達した。

【０００８】すなわち、本発明は、母材表面に硬質皮膜を被覆してなる工具であって、その硬質皮膜は、金属成分のみの原子％が、Ｓｉ：５～５０％、実質的に残部、Ａｌ、Ｗの１種もしくは２種で構成される窒化物であるａ層と、金属成分のみの原子％が、Ａｌ：４０～６０％、Ｓｉ：１０％越え、２０％以下、実質的に残部がＴｉで構成される窒化物であるｂ層とが、それぞれ一層以上交互に被覆されたものであり、かつｂ層が被覆母材表面直上にあることを特徴とする工具である。なお、本発明の硬質皮膜のａ層は、０．１～３μｍの層厚であることが好ましく、更に本発明の硬質皮膜は、物理蒸着法により被覆されたことが好ましい。

【０００９】

【発明の実施の形態】はじめに請求項中記載の硬質皮膜のａ層に関して、その構成要件について詳しく述べる。

【００１０】一般にＴｉＡｌＮ皮膜は、大気中で酸化テストを行うと、皮膜表面近傍のＡｌが最表面に外向拡散し、そこでＡｌ酸化物層を形成する。一般に、このＡｌ酸化物層の形成が耐酸化性向上の理由と言われているが、この時、Ａｌ酸化物層の直下には、Ａｌを含有しない非常にポーラスなＴｉ酸化物の層が形成する。

【００１１】本発明者の研究によれば、上記のＴｉＡｌＮ皮膜は、静的な酸化試験においては、最表面に形成されたＡｌ酸化物の層が、皮膜の酸化を進行させる酸素の内向拡散に対し保護膜として機能するが、実際に工具へ適用した場合では、加工時の応力や衝撃等により、最表面のＡｌ酸化物の層は、その直下のポーラスなＴｉ酸化物の層より容易に剥離してしまい、酸化の進行に対し十分その効果を発揮していないことが認められた。これらより、皮膜の耐酸化性を改善するだけでなく、酸化時、酸化保護膜の直下に形成されるポーラスな層を緻密な形態に改善することで、更に硬質皮膜の性能を向上できることが予想された。

【００１２】そこで、上記考えに基づき検討を行った結果、金属成分が、適量のＳｉと、実質的に残部がＡｌ、Ｗの１種もしくは２種で構成される窒化物の皮膜は、従来のＴｉＡｌＮ皮膜に対し極めて耐酸化性に優れているだけでなく、酸化後、最表面には酸化保護膜となるＳｉを主体に含有する非常に緻密な酸化物層を形成し、また、その直下には酸化保護膜の剥離原因となるポーラスな酸化物層を形成しないということを確認した。

【００１３】上記効果を得るには、金属成分のみの原子％で、Ｓｉが、実質的に残部であるＡｌ、Ｗの１種もしくは２種に対し、５％以上添加されていなければならず、逆に５０％を越えて含有すると、皮膜の密着性低下が顕著になり、工具としての使用に耐えられなくなる。Ｓｉの望ましい範囲は、皮膜の金属成分のみの原子％で１０～４０％である。

【００１４】本発明にある硬質皮膜のａ層は、その層厚が０．１μｍ～３μｍで有ることが好ましい。ａ層の層厚が０．１μｍ未満の場合、酸素の内向拡散に対して層厚が十分でない場合があり、耐酸化性向上効果が顕著に表れない。また、ａ層の層厚が３μｍを越えると使用中にａ層の破壊もしくは剥離が発生する機会が増加する。そのためａ層の層厚は０．１μｍ～３μｍが好ましい。

【００１５】上記ａ層は、静的および動的条件下において優れた耐酸化性を有すものの、母材との密着性においては十分でない。そのため、母材表面直上には、密着性、耐摩耗性、耐酸化性等をバランス良く適度に有す皮膜である、請求項中に記載のｂ層を被覆することが必要である。

【００１６】ｂ層におけるＡｌの役割は、皮膜の耐摩耗性および耐酸化性を向上させることである。皮膜中におけるＡｌ含有量が少ないほど、母材と皮膜の密着性は良好となるが、皮膜の金属成分のみの原子％で、Ａｌが４０％未満となると、皮膜の耐摩耗性、耐酸化性を向上させる効果が得られない。しかしながら、６０％を越えて含有すると、母材と皮膜の密着性が劣化するだけでなく、逆に皮膜の硬さも低下し、工具として必要な耐摩耗性が得られない。そのため、密着性、耐摩耗性、耐酸化性をバランス良く得るためには、ｂ層のＡｌ含有量を、皮膜の金属成分のみの原子％で、４０～６０％に調整することが重要である。

【００１７】また、上記ｂ層においてＳｉは、耐酸化性、皮膜硬さの向上に効果がある。この効果を得るには、金属成分のみの原子％で、Ｓｉを１０％を越えて含有させることが必要であるが、２０％を越えて含有させると、ｂ層の密着性が著しく低下する。よって、工具へ適用した場合、密着性、耐摩耗性、耐酸化性を高次元でバランス良く得るには、ｂ層のＳｉ含有量を、皮膜の金属のみの原子％で、１０％を越えて２０％以下にすることが重要である。

【００１８】以上のように本発明の工具においては、母材との密着性、皮膜自体の耐摩耗性および耐酸化性を高次元でバランス良く有すｂ層を母材表面直上に被覆し、その上に著しく耐酸化性に優れるａ層を被覆することが極めて重要であり、その結果、低潤滑下加工や高速加工に対し、十分に使用可能となる切削工具、金型等を得ることができる。また、母材表面直上にｂ層を被覆した後、ａ層ならびにｂ層をそれぞれ交互に積層した多層皮膜によっても同様の効果が得られる。

【００１９】本発明の工具に被覆される硬質皮膜は、その被覆方法については、特に限定されるものではないが、被覆母材への熱影響、工具の疲労強度、皮膜の密着性等を考慮した場合、比較的低温で被覆でき、被覆した皮膜に圧縮応力が残留するアーク放電方式イオンプレーティング、もしくはスパッタリング等の被覆母材側にバイアス電圧を印加する物理蒸着法であることが望ましい。

【００２０】

【実施例】次に実施例に基づき詳細に説明するが、本発明は下記実施例によって限定を受けるものではなく、本発明の要旨を逸脱しない範囲で任意に変更が可能であり、それらはいずれも本発明の技術的範囲に含まれる。

【００２１】小型アークイオンプレーティング装置を用い、金属成分の蒸発源である各種合金製ターゲット、ならびに反応ガスとしてN_2ガスを用い、被覆基体温度４００℃、反応ガス圧力３．０Ｐａの条件下にて、被覆基体である外径８ｍｍの超硬合金製６枚刃エンドミルに、－５０Ｖの電位を印加し、１分間に５回転させながら、まずｂ層として被覆基体表面直上に成膜し、全皮膜の厚みが約４μｍとなるように成膜を行った。

【００２２】得られた硬質皮膜は、オージェ分光分析法による皮膜組成の定量、皮膜断面の走査型電子顕微鏡観察による各層厚の測定を行い、さらに次に示す乾式高速切削条件にて切削性能を評価した。この時、刃先の欠けないしは摩耗等により工具が切削不能となるまで加工を続け、この時の切削長を工具寿命とした。表１、２に本発明例および比較例に関する硬質皮膜の詳細およびその切削性能評価結果を示す。また、併せて表３に従来例の評価結果について示す。

【００２３】（切削条件）
工具　　：超硬合金製６枚刃エンドミル　外径８mm
切削方法：側面切削ダウンカット、エアーブロー
被削材　：ＳＫＤ１１（硬さ６０ＨＲＣ）
切り込み：Ａｄ　１２mm×Ｒｄ　０．４mm
切削速度：１５０ｍ／ｍｉｎ
送り　　：０．０３mm／ｔｏｏｔｈ

【００２４】
【表１】

		a層		b層		総積層数（a層＋b層）	工具寿命 (m)
		皮膜組成	層厚 (μm)	皮膜組成	層厚 (μm)		
本発明例	１	$(Al_{0.76}Si_{0.24})N$	１．０	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	３．０	２	５０．８
	２	$(Al_{0.76}Si_{0.24})N$	０．４	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	０．４	１０	４９．８
	３	$(W_{0.87}Si_{0.13})N$	１．０	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	３．０	２	４９．８
	４	$(Al_{0.67}Si_{0.33})N$	１．０	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	３．０	２	５０．２
	５	$(Al_{0.40}W_{0.37}Si_{0.23})N$	０．２	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	０．２	２０	５０．２
	６	$(Al_{0.76}Si_{0.24})N$	０．５	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	３．５	２	５０．４
	７	$(Al_{0.40}W_{0.37}Si_{0.23})N$	１．０	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	３．０	２	５０．２
	８	$(Al_{0.67}Si_{0.33})N$	０．２	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	０．２	２０	５０．２
	９	$(W_{0.87}Si_{0.13})N$	０．２	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	０．２	２０	４９．６
	１０	$(W_{0.78}Si_{0.22})N$	０．５	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	３．５	２	５０．２
	１１	$(Al_{0.86}Si_{0.14})N$	０．４	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	０．４	１０	５０．２
	１２	$(W_{0.87}Si_{0.13})N$	０．２	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	０．６	１０	４９．８
	１３	$(W_{0.78}Si_{0.22})N$	１．０	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	３．０	２	５０．８
	１４	$(Al_{0.76}Si_{0.24})N$	０．２	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	０．６	１０	５０．０
	１５	$(Al_{0.86}Si_{0.14})N$	１．０	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	３．０	２	５０．２
	１６	$(W_{0.78}Si_{0.22})N$	０．５	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	３．５	２	５０．２
	１７	$(Al_{0.76}Si_{0.24})N$	０．２	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	０．１	２０	４９．６
	１８	$(Al_{0.67}Si_{0.33})N$	１．０	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	３．０	２	５０．８
	１９	$(W_{0.78}Si_{0.22})N$	０．４	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	０．４	１０	５０．２
	２０	$(Al_{0.76}Si_{0.24})N$	１．０	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	３．０	２	５０．６
	２１	$(W_{0.78}Si_{0.22})N$	０．２	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	０．２	２０	５０．０
	２２	$(Al_{0.40}W_{0.37}Si_{0.23})N$	０．５	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	３．５	２	５０．４
	２３	$(Al_{0.86}Si_{0.14})N$	０．５	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	３．５	２	５０．４
	２４	$(W_{0.78}Si_{0.22})N$	０．２	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	０．６	１０	４９．８
	２５	$(W_{0.87}Si_{0.13})N$	０．５	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	３．５	２	４９．６

【００２５】
【表２】

		a層		b層		総積層数（a層＋b層）	工具寿命 (m)
		皮膜組成	層厚 (μm)	皮膜組成	層厚 (μm)		
比較例	３１	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	０．４	$(Al_{0.76}Si_{0.24})N$	０．４	１０	５．０
	３２	$(Al_{0.76}Si_{0.24})N$	１．０	$(Ti_{0.44}Al_{0.52}Si_{0.04})N$	３．０	２	３５．８
	３３	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	１．０	$(W_{0.78}Si_{0.22})N$	３．０	２	４．８
	３４	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	０．４	$(W_{0.87}Si_{0.13})N$	０．４	１０	４．４
	３５	$(W_{0.40}Si_{0.60})N$	１．０	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	３．０	２	３０．４
	３６	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	３．０	$(Al_{0.76}Si_{0.24})N$	１．０	２	５．４
	３７	$(W_{0.99}Si_{0.01})N$	１．０	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	３．０	２	３１．６
	３８	$(Al_{0.98}Si_{0.02})N$	１．０	$(Ti_{0.33}Al_{0.54}Si_{0.13})N$	３．０	２	３２．２
	３９	$(W_{0.78}Si_{0.22})N$	０．５	$(Ti_{0.44}Al_{0.52}Si_{0.04})N$	３．５	２	３５．６
	４０	$(Al_{0.76}Si_{0.24})N$	１．０	$(Ti_{0.48}Al_{0.52})N$	３．０	２	３５．８
	４１	$(Al_{0.37}Si_{0.63})N$	０．５	$(Ti_{0.43}Al_{0.44}Si_{0.13})N$	３．５	２	２９．８

【００２６】
【表３】

		皮膜構造および組成	工具寿命 (m)
従来例	５１	$(Ti_{0.52}Al_{0.48})N$ 単一層	２７．６
	５２	TiN（基体側1.0μm）＋ $(Ti_{0.52}Al_{0.48})N$（表面側3.0μm）	２４．４
	５３	$(Ti_{0.41}Al_{0.59})N$ 単一層	２８．２
	５４	TiN（基体側1.0μm）＋ $(Ti_{0.41}Al_{0.59})N$（表面側3.0μm）	２７．６

【００２７】表１、２および表３に示すように、本発明例は、比較例ならびに従来例と比べ工具寿命が著しく延長していることがわかる。表２中の比較例３１、３３、３４、３６については、皮膜の組成については本発明に含まれるものであるが、皮膜の層構造が異なるため、早期に皮膜と母材の界面より剥離が生じ、極めて短寿命の結果となった。また、比較例３５、４１は、ａ層のＳｉ含有量が多く、切削初期の段階でａ層の剥離が生じたた

め、従来例とほぼ同等の工具寿命になった。

【００２８】一方、比較例３２、３７、３８、３９、４０については、いずれも従来例に比べ工具寿命は優れる結果となったが、本発明例のような著しい改善効果は認められなかった。これは、比較例３２、３７、３８、３９では、ａ層もしくはｂ層におけるＳｉ含有量が少ないこと、比較例４０については、ｂ層にＳｉを含有していないことで、皮膜の耐酸化性が本発明例ほど十分に改善されなかったためと考える。

【００２９】

【発明の効果】本発明の硬質皮膜を被覆してなる工具は、従来のＴｉＡｌＮ皮膜を被覆してなる工具に比べ、優れた耐酸化性、耐摩耗性を有すことから、金属加工の高速化に対応することが可能であり、生産性の向上に極めて有効である。